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STUDY OF THE EARTH-TYPE PLANETS

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ABSTRACT

The article discusses work by the USSR Academy of Sciences Commission on Planetary Physics in 1964 and 1965. Atmospheric pressure investigations by photometric and polarimetric means were conducted. Aerosol influence is considered. Values for the Mars and Venus atmospheres are presented. Various individual studies were presented by their authors.

Great interest in earth-type planets--Mars and Venus-- has been generated recently by great progress in the fields of space investigation. Many observations of these planets have already been performed by instruments on rockets and space stations, and interesting results have been obtained. /53*

Thorough study of Mars and Venus is necessary to permit landing automatic stations on their surfaces.

In the USSR a Work Group for study of earth-type planets was established by the Astronomic Council of the USSR Academy of Sciences for coordinating investigations within the framework of the Commission on Planetary Physics. At the Group's yearly meetings, scientists learn of recent accomplishments and plan

*Numbers given in margin indicate pagination in original foreign text.

future studies. Such a meeting of the Group took place in Kiev in 1964 and at the Crimean Astrophysical Observatory in 1965.

Spectroscopic, photometric and polarimetric investigation methods yielding new data concerning physicochemical characteristics of the Martian and Venusian atmospheres received most attention at these meetings.

Atmospheric Pressure

Determining atmospheric pressure on the Martian surface by photometric observation leads to calculating optical density of the atmosphere by formulas for the theory of light-scattering in planetary atmospheres.

The Soviet astronomers N. N. Sytinskaya, V. V. Sharonov, N. P. Barabashov, et al. at different times arrived at agreeing results of relative values of optical thickness of the Martian atmosphere. Atmospheric density at the surface was equal to 60 mm Hg.[1] Such a value was also obtained by polarization observations.

However, now spectroscopists have worked on determining atmospheric pressure on Mars. Using bands of molecular absorption (belts of carbonic gas), many American astronomers, as well as the Soviet V. I. Moroz, have found that pressure on Mars is approximately one third that anticipated from photometric and polarimetric measurements.

What is wrong? Which value should be given preference?

At the Kiev conference V. I. Moroz, N. N. Sytinskaya and E. G. Yanovitskiy presented the opinion that pressure determination using optical atmospheric

[1] Here and later the value for pressure is given in mm Hg, calculated by aneroid barometer. The mercury barometer here is not suitable, because its indications depend on gravity, which varies for different planets. Ed.

thickness leads to values known to be increased. The problem is that these very photometric and polarimetric observations of Mars, by which atmospheric optical thickness was obtained, indicate the constant presence in the Martian atmosphere of hard (aerosol) particles--dust and ice crystals. This contamination of the Martian atmosphere considerably increases its optical thickness. In other words, we can never determine the optical thickness of only the gaseous atmosphere of Mars, although the true gas component must enter into the formulas for determining atmospheric pressure. What is important about the spectroscopic /54 method is that it is free of the influence of aerosol particles and yields information on the strictly gaseous atmosphere.

E. G. Yanovitskiy has conducted quite indicative calculations for evaluating the influence of aerosols on results of determinations of atmospheric pressure by optical thickness. He used measurements of optical thickness of the earth's atmosphere for calculating atmospheric pressure at the earth's surface. Instead of the 760 mm Hg, he obtained values of ± 1700 mm, which definitely is explained by the contamination of earth's atmosphere by very small hard particles with radii of $\pm 10^{-6}$ cm. Their presence in the background of molecular mixtures can almost not be shown, because they disperse solar light by almost the same law as gas molecules.

Thus, the spectroscopic method of determining atmospheric pressure for planets with atmospheres containing aerosols apparently is more basic, and we must take 15-20 mm Hg as the more probable values of atmospheric pressure on the Martian surface.

Recently A. V. Morozhenko concluded an extensive series of measurements of Martian polarization by photoelectrical means. These measurements allowed him to determine atmospheric pressure using polarization properties of the Martian

atmosphere in various regions of the spectrum. Pressure at the surface did not exceed 15 mm Hg.

We must assume that even these pressure values are exaggerated; in particular, measurement results depend on the optical properties of the Martian surface.

Thus, if we verify information on the roughness of the Martian surface, this leads to decrease in calculated values of the optical thickness of its atmosphere and simultaneously to decrease in evaluation of the amount of aerosol particles. In this respect we should note that data from Mariner IV showed Martian surface atmospheric pressure as equal to ± 10 mm Hg.

V. I. Moroz considers the atmospheric pressure on the surface of Venus equal to 10 atm. Observations give the value for pressure only for the upper limits of the cloud layer--20 mm Hg, and pressure for a determined model atmosphere can be found by calculation.

Chemical Composition and Some Properties of the Atmospheres of Venus and Mars

The thorough reports by V. K. Prokof'yev "Analysis and Perspectives of Spectroscopic Investigations of Venus and Mars" and V. I. Moroz "Review of Infrared Spectroscopy of Venus and Mars" preceded discussion of this question.

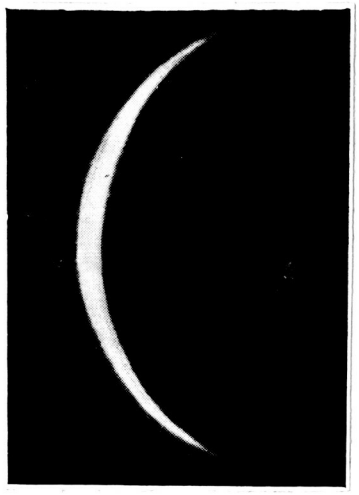
The presence of carbon dioxide, oxygen and water vapor is now reliably established, and on Mars that of carbon dioxide and water vapor.

Recently variations in intensity of carbon dioxide belts in the atmosphere of Venus were observed. Moreover, observers reported the appearance of dark and light formations on the disk of Venus in the shortwave region of the spectrum. The majority of dark spots are unstable and only 2 or 3 days after appearance lose contrast and disappear on the bright background of the planet.

However, stable spots with long duration, visible for several days, also appear. Unfortunately, as a result of the instability of the terrestrial atmosphere, we have not yet succeeded in obtaining the spectrum of the dark spots, thus reducing the number of hypotheses on their origin. Meanwhile there are no polarimetric observations of individual spots, although as a whole the study of polarization of Venus correctly shows the presence of clear particles--small crystals (of ice ?) or water droplets with 2 μ diameters.

The light spots also observed in the ultraviolet rays near the limits of the terminator lines (borders of light and dark) almost always occupy large /55 areas and can be observed for several weeks. Some observers believe that these spots are at the poles. Light spots considerably smaller than "polar" are sometimes observed near medium-temperature zones. As a rule, the spots are weakly defined and endure briefly. No one doubts their reality, but sometimes reports appear in the literature on the appearance of small, rather bright spots in various parts of the illuminated portion of the disk of Venus. Their existence is all the more questionable, because the observers themselves sometimes equate these spots with flares.

V. I. Moroz briefly considered infrared radiation reception presently extant for various regions of the infrared spectrum, and he presented basic physical characteristics of the atmospheres of Venus and Mars (chemical composition, pressure, temperature, aerosol particle dimensions, etc.). He emphasized the importance of resolving such problems as study of variations in carbon dioxide amounts with phase and by the disk of Venus, to give accuracy of its content in the atmospheres of Venus and Mars by intensity of unsaturated belts, pursuing spectral observations of Venus and Mars with high solution in the infrrared window of Earth's atmosphere clearness for 8-13 μ waves.

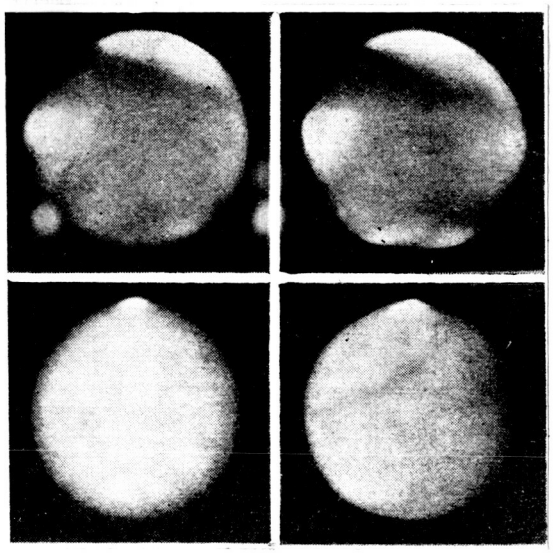


Photograph of Venus obtained by Slayfer at Flagstaff Observatory.

The 1965 Work Group meeting decided to conduct future systematic cooperative observations of Venus and Mars, the necessity of which was discussed in many reports.

A. V. Morozhenko and M. M. Pospergelis discussed polarimetric studies of Venus and Mars. A. V. Morozhenko reported new results of investigations of the dependence of the degree of polarization of Mars on wavelength and phase angle obtained at the Main Astronomical Observatory of the Uk.SSR Academy of Sciences. These studies provided evaluation of atmospheric pressure at the surface of Mars (15 mm Hg), which we have already discussed. He also indicated the need for further polarimetric studies of the planets in various spectral regions parallel with photometric studies. Such material will be quite valuable from the point of view of the application of the theory for determining physical characteristics of the planets' atmospheres.

M. M. Pospergelis described an instrument he devised, an automatic polarimeter, and discussed perspectives for its application.



Photograph of Mars obtained with blue rays in 1954 (above) and 1956 (below), indicating "blue layer" structure variability.

Members of the conference attentively listened to the report by L. A. Mitrofanova on laboratory investigation of molecular spectra for absorption of various gases performed at the USSR Academy of Sciences Main Astronomical Observatory at Pulkova. These works are most important in interpretation of spectral observations of the atmospheres of the planets, and the Work Group recommended their continuation.

I. N. Minin spoke on theoretical works in the laboratory of the Leningrad University which will later permit interpretation of polarimetric observations of Mars from the Main Astronomical Observatory of the Uk.SSR Academy of Sciences. The Work Group approved these studies and recommended broadening them, including photometric and spectrophotometric observations.

N. A. Kozyrev emphasized the importance of systematic observations of the nocturnal side of Venus (obtaining spectra and photographs to discover sources of information related to lower layers of cloud cover).

New methods of observing Venus and Mars--photoelectric scanning, obtaining short-exposure photographs by television, received great attention. A report on developing new types of infrared receivers at the Uk.SSR Academy of Sciences Institute of Physics received great attention.

Because terrestrial observations allow us to resolve only limiting questions, the necessity for broader development of extraterrestrial observations of planets was noted at the conference.